TACOM

Mobility and Firepower for America's Army

Advanced Acoustic Sensor Technologies

NDIA Symposium

Session III Advanced Technologies

20 June 2001

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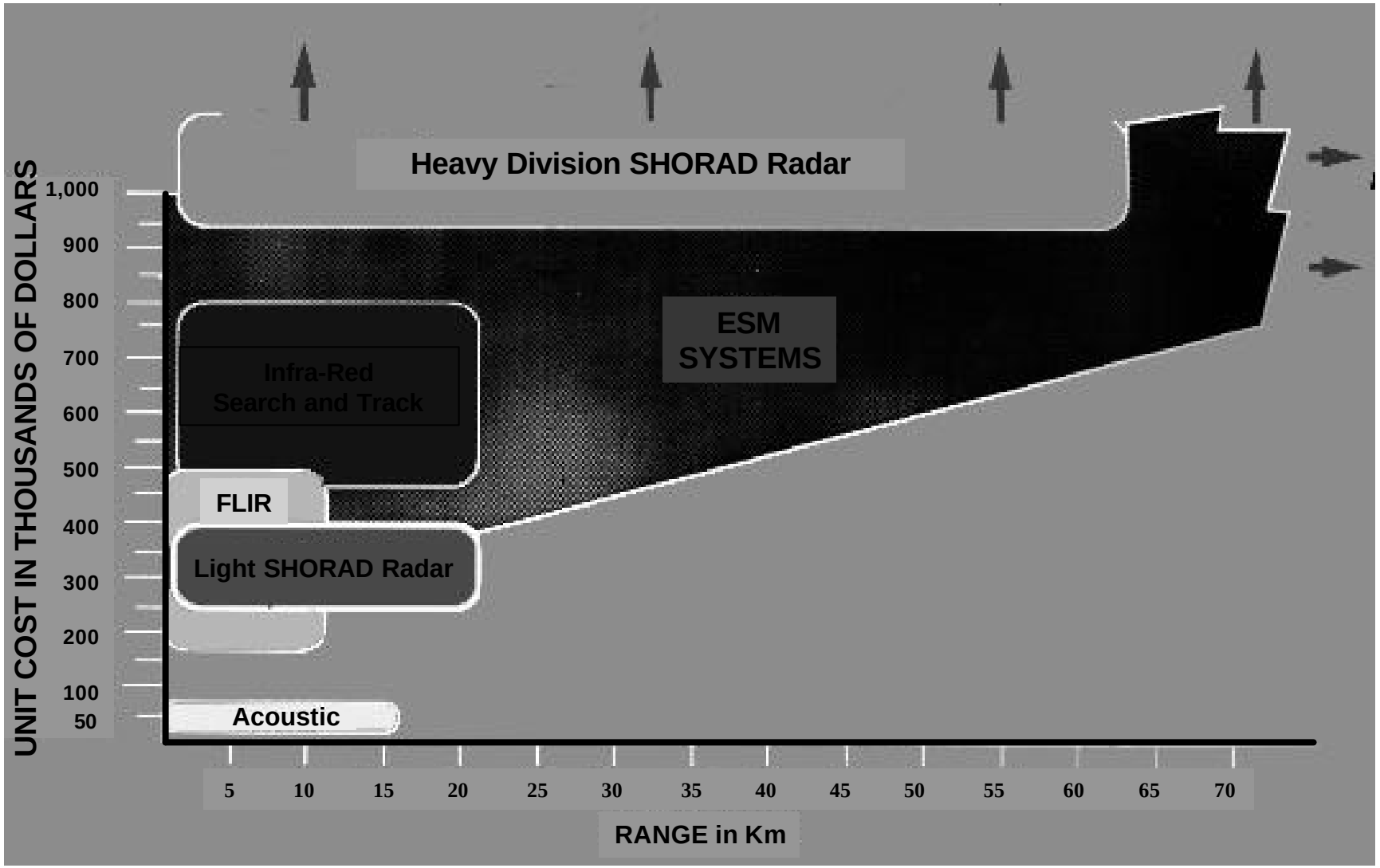
OUTLINE

- **BACKGROUND**
  - **WHY ACOUSTICS**
  - **TECHNOLOGY EXPLOITED**
  - **PRIOR ARDEC PROGRAMS**
- **PRIOR TECHNOLOGY/PROGRAMS**
  - **FAAD**
  - **HELO & BAT**
  - **COUNTER SNIPER**
  - **RFPI**
- **CURRENT TECHNOLOGY/PROGRAMS**
  - **NINOX**
  - **RAPTOR**
    - **CLASSIFIER**
    - **TARGET COUNTER**
  - **TECH BASE (6.2)**
    - **ACOUSTIC COUNTER BATTERY SYSTEM (ACBS)**
    - **ACOUSTIC/SEISMIC MODELING**
    - **NETWORKED DISTRIBUTED SENSORS**

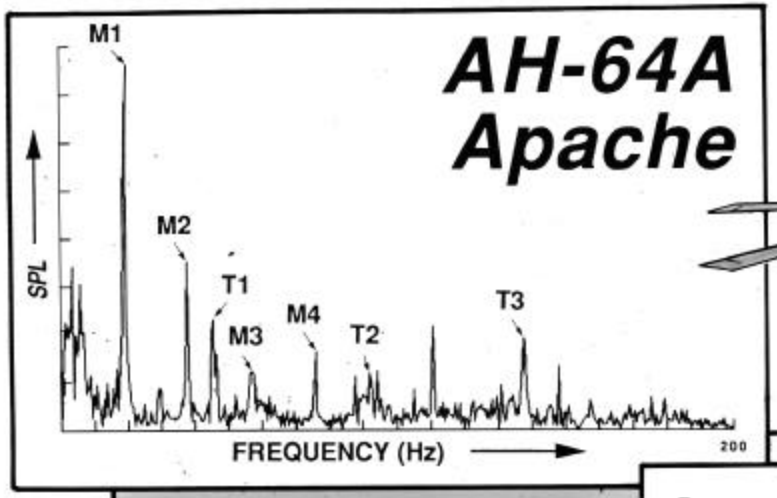
Army Benefits

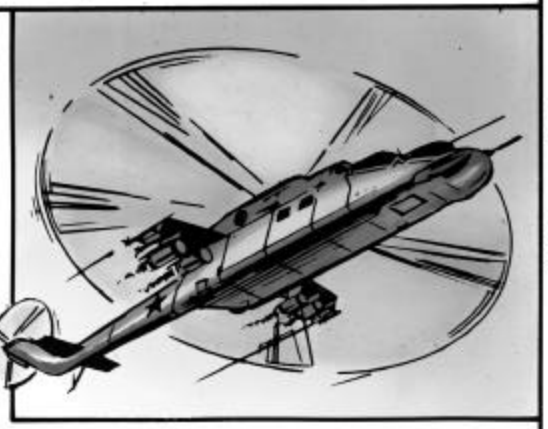
- Passive
- Day/Night/Adverse Weather
- NLOS Threat Target Detection
- NC-IFF, PHID (Avoids Fratricide)
- Acquire Threats at Stand-off Ranges
- Support Shoot-on-the-Move
- Range to Target

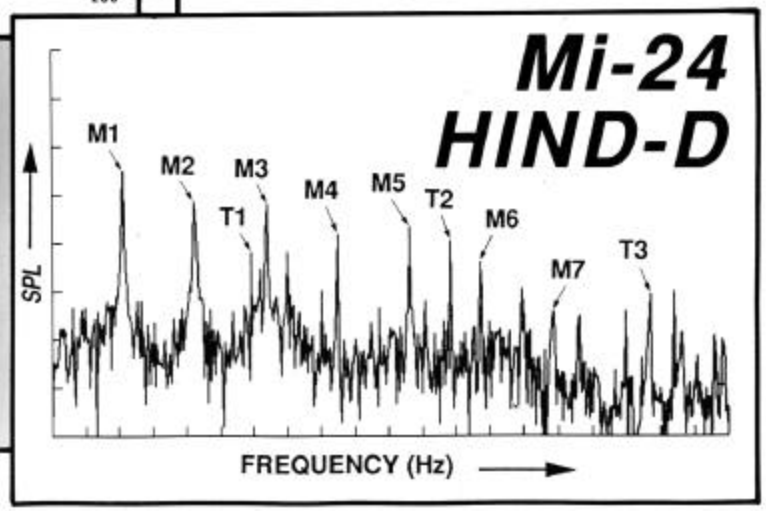
BATTLEFIELD SENSOR COMPARISON



Helicopter Acoustic Signatures







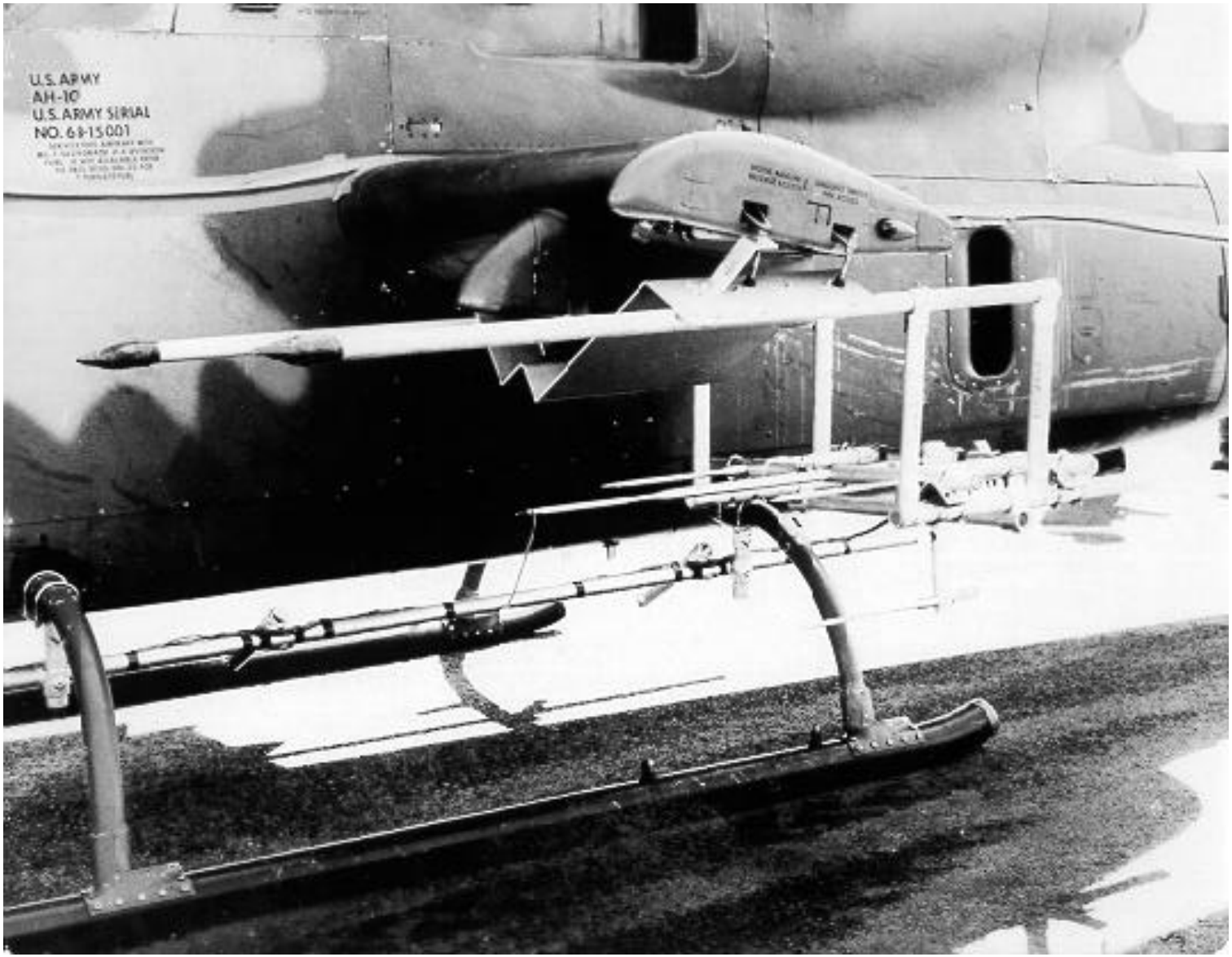
Concept Definition

- ***System Description***
  - Acoustic Sensors for Target Detection, Tracking and Location
- ***Unique Capabilities***
  - All weather, Day/Night, All Terrain Target Tracking
  - Provide Situational Awareness
  - Low Cost
  - BCID (Battlefield ID/Classification)
  - Passive and Resists CM
  - Promotes Fratricide Avoidance
- ***Operational Capability Requirements (OCRs) Addressed***
  - BC01, BC09, DSA06, DSA12, DSA13, DBS01A, DBS03, DBS04A, DBS05A, DBS10, DBS12, MTD04, MTD14, MTD22, EEL13

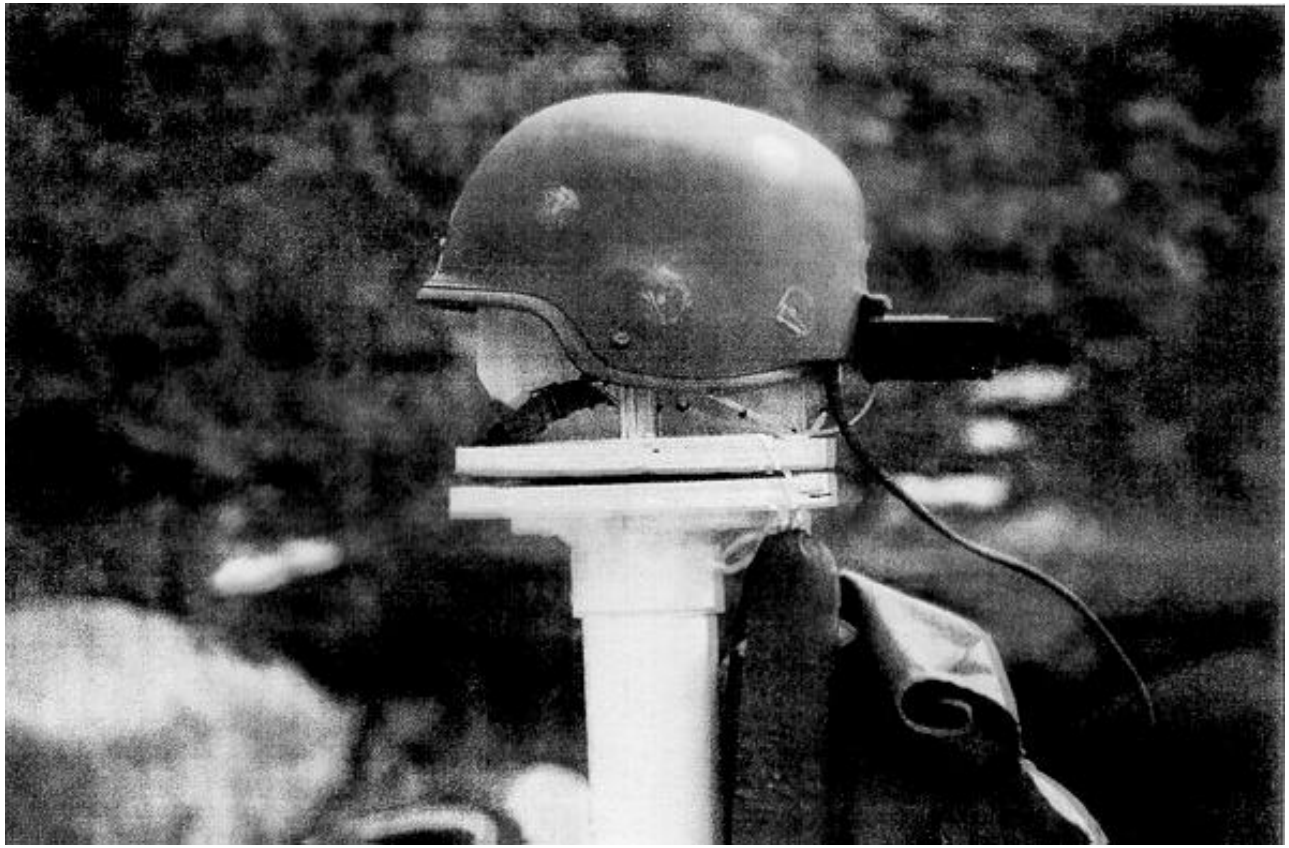
Operational Benefit

Low cost, passive acoustic sensor systems provide non-line-of-sight situational awareness and target acquisition and handoff to weapon systems fire control. New integrated warfighting capabilities are provided through sensor fusion and battlefield digitization.

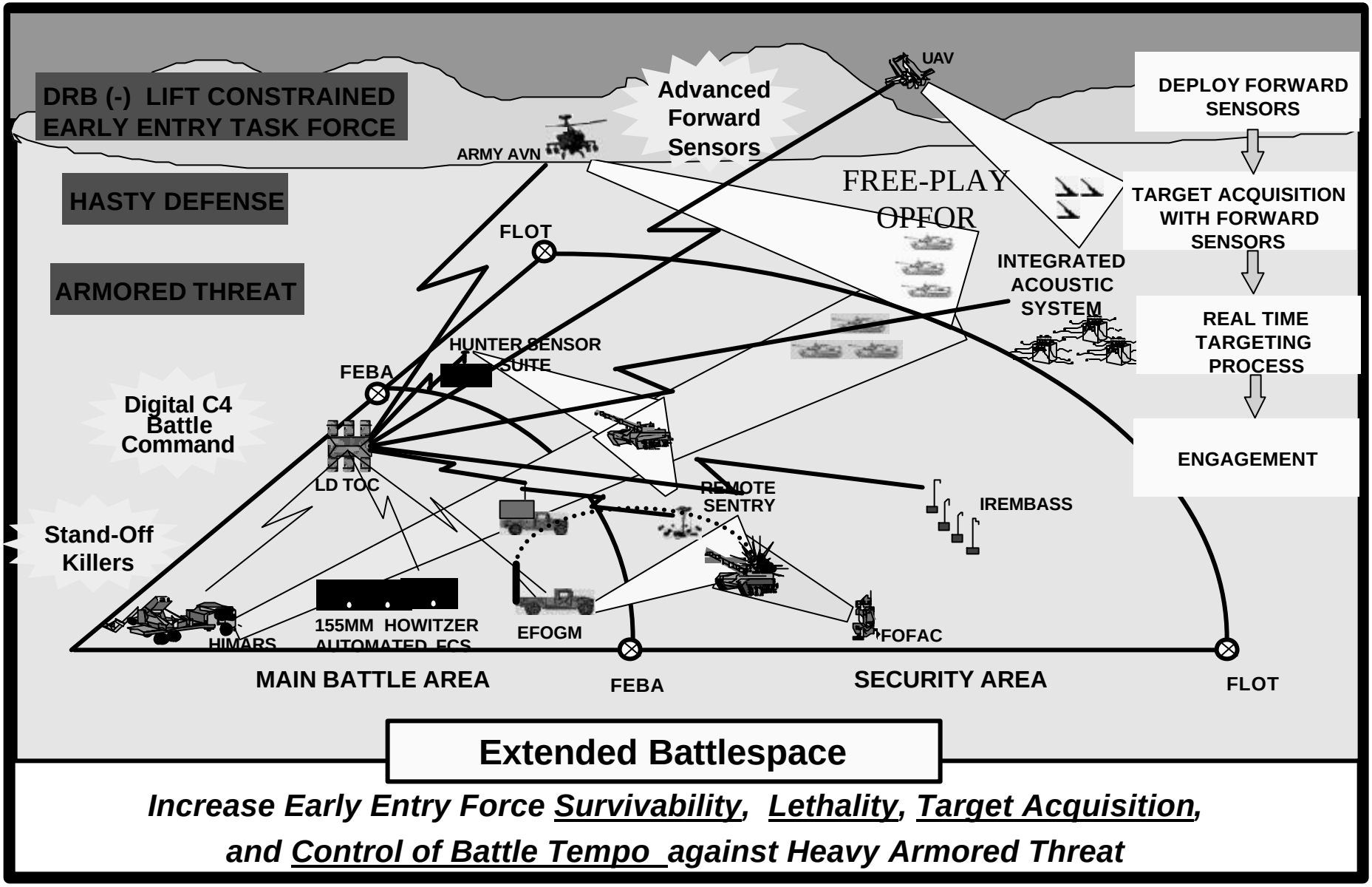

CHARTER
RENTAL
INSTRUCTION


U.S. ARMY
AH-1G
U.S. ARMY SERIAL
NO. 68-15001

BBN-12 Channel Acoustic Helmet Heading Sensor



RFPI ACTD HUNTER/ STANDOFF KILLER CONCEPT



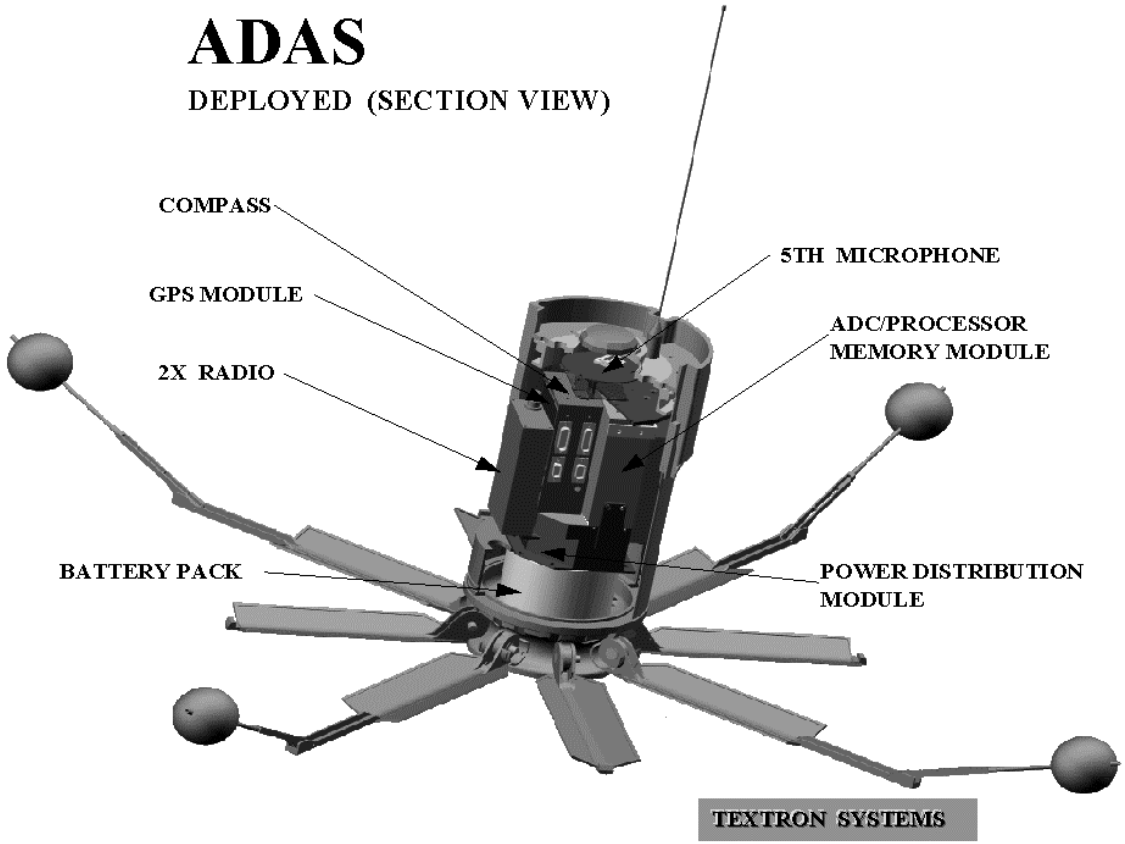
Extended Battlespace

Increase Early Entry Force <u>Survivability</u>, <u>Lethality</u>, <u>Target Acquisition</u>, and <u>Control of Battle Tempo</u> against Heavy Armored Threat

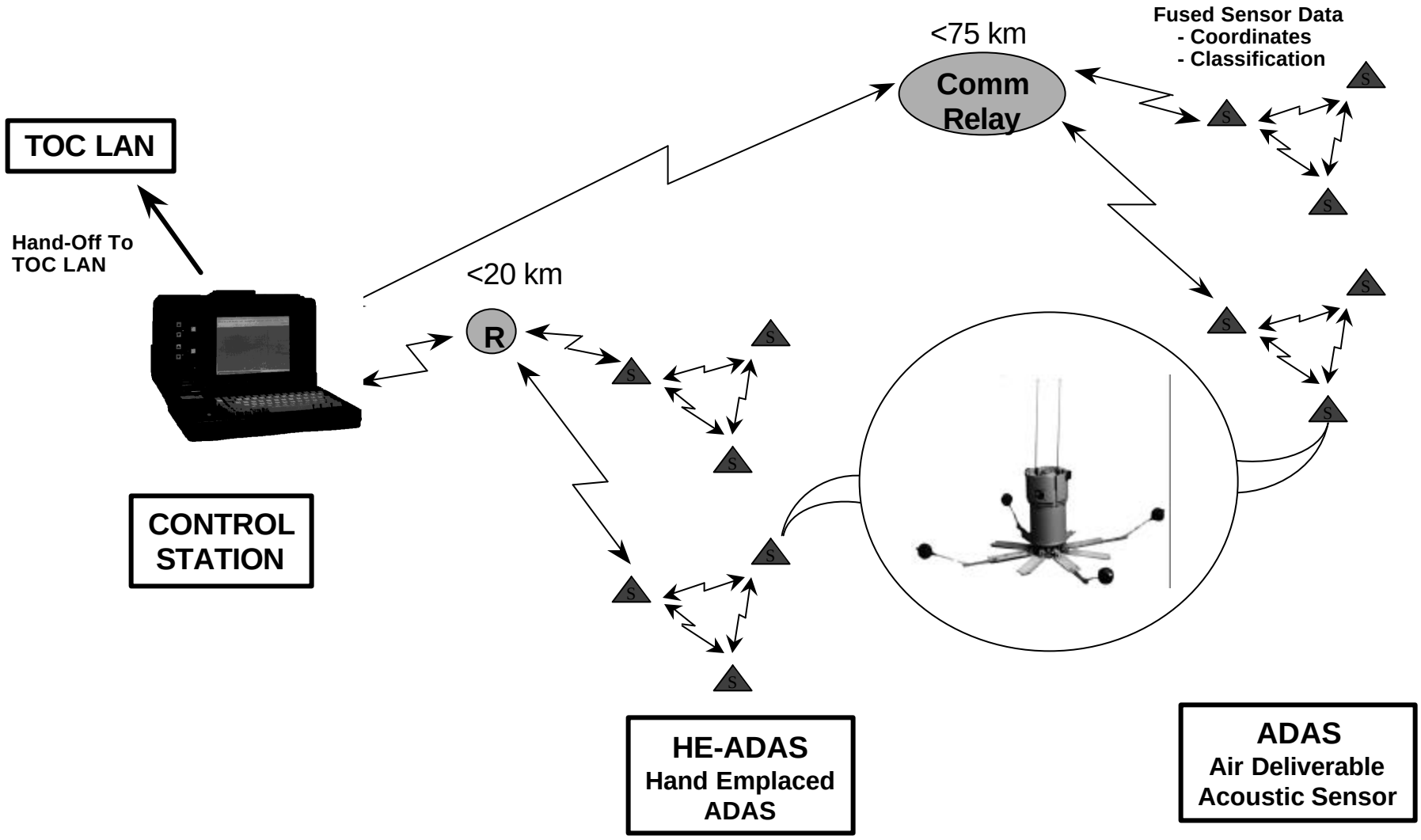
IAS Array Configuration

Air Deliverable Acoustic Sensor

- Detect, track, and classify ground/air vehicles
- 4' aperture, 5 mic array, DSP
- Hand emplace or air deploy w/ optional parachute
- Self mapping via GPS
- Separate long haul and short haul data radios



IAS System Components



Acoustic CRADA (TSD & ARDEC)

ARDEC to develop improved air-acoustic signal processing techniques for IAS/ADAS

- **Advanced detection & classification methods**
- **Field test facility support (ADAS units, site, drivers, etc.)**
- **GFE ADAS units for Operational Testing**

•Textron to support & implement

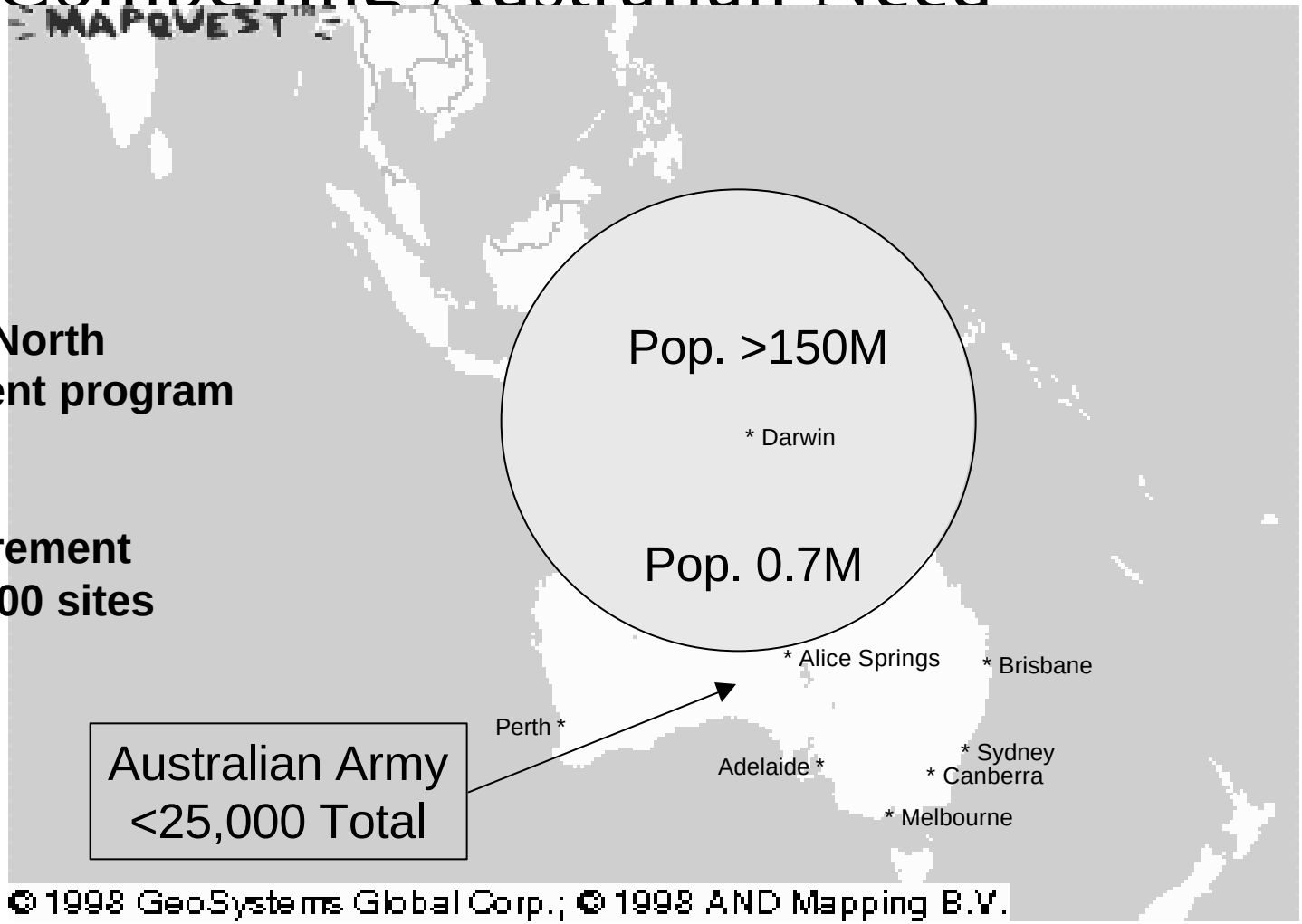
- **Tech support & consultation to above tasks**
- **Provide GDAS to ARDEC for Development Testing**
- **Implement ARDEC algo improvements in ADAS S/W**
- **Field test support (personnel, met, truth, etc.)**

Compelling Australian Need

Ninox UGS

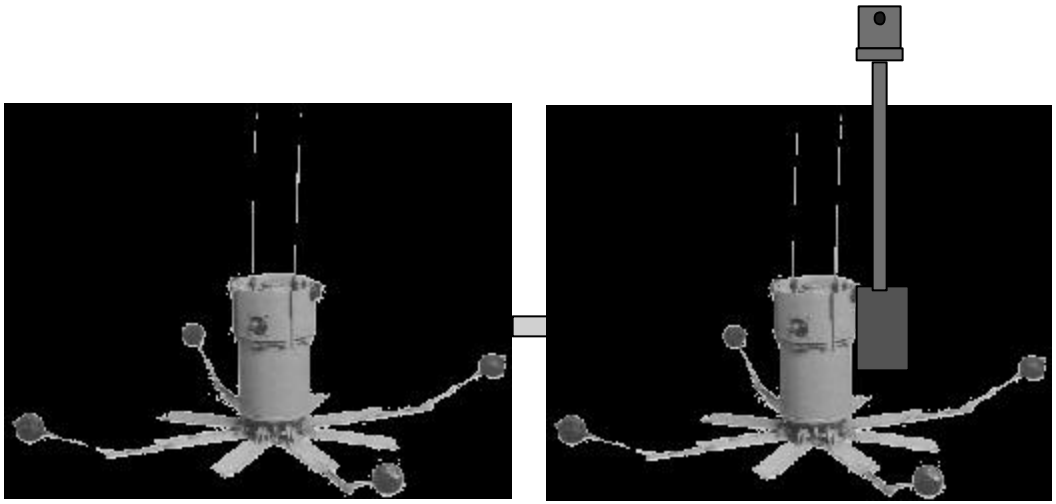
70 sites in the North
funded in current program
~$20-33M US

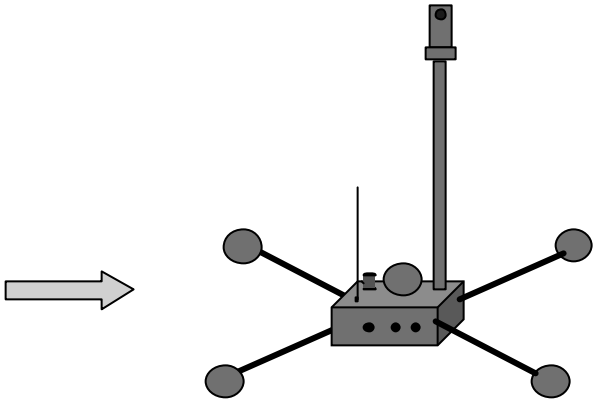
Eventual requirement
may exceed 1000 sites
>$200M US



Development Plan

Current Hardware 1998 **Confirmatory Demo Nov,1999** **Deliveries 2001-2002**





ADAS

Prototype OASIS

- **ADAS H/W & S/W modifications funded by Contractors**

OASIS Deliverables

- **Development completed under NINOX UGS contract**

Some Key Features

- Beamforming Acoustic Array ***(TSD)***
  - Long Range Discrimination & Tracking of Motor Vehicles
- Distributed Mini-Sensors ***(RACAL->Thompson->THALES)***
  - Seismic, Magnetic, & Passive Infrared
  - Personnel Detection & Back-Up for Acoustics
- Precision Cued Day/Night Electro-Optics ***(TENIX)***
  - Operator in the Loop Target Recognition
- Satellite Based Long Haul Communications
  - Operation in Remote Areas - Unlimited Range
- Advanced Integrated Control Station
  - Remote Situational Awareness

Terrain Commander

OASIS - Optical Acoustic SATCOM Integrated Sensor

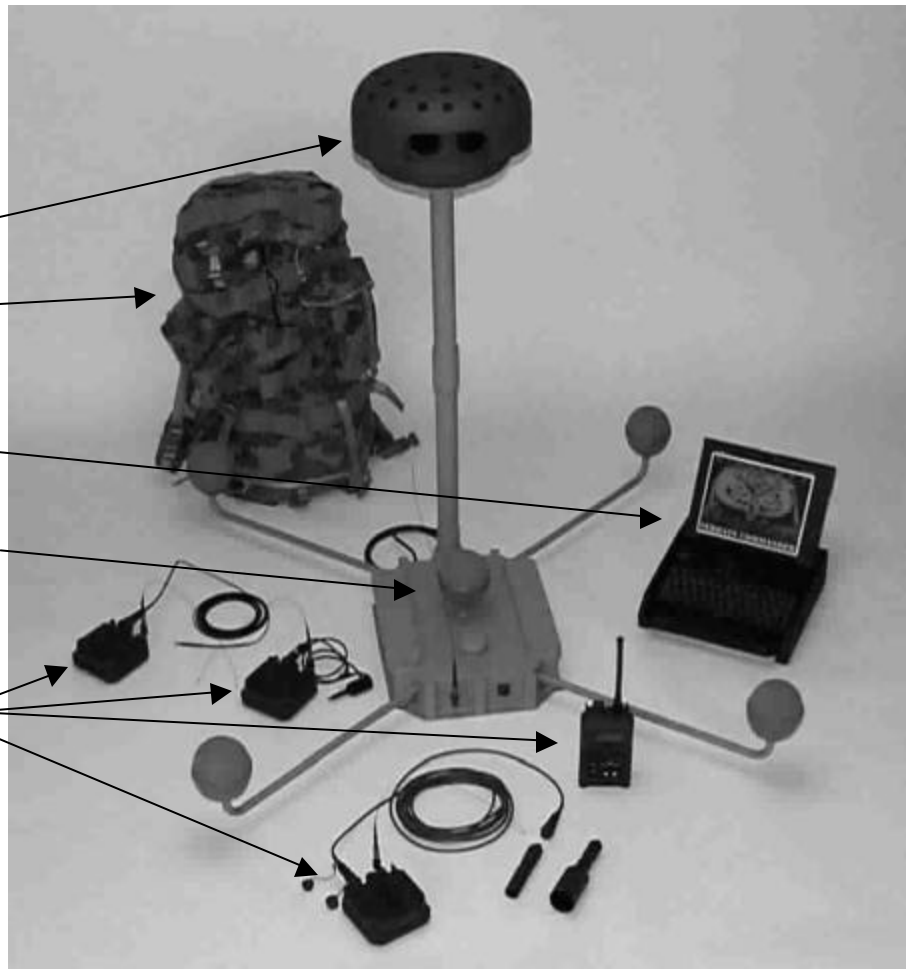
- OASIS Day/Night Electro-Optics Head

- Rucksack

- Central Monitoring Facility (CMF)

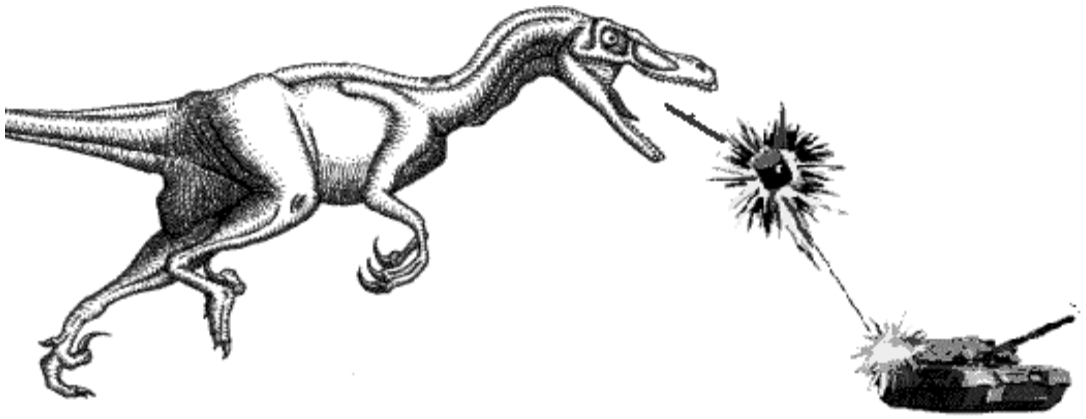
- OASIS Base Unit w/ 5 Mic Beamforming Acoustic Sensor & Satellite Comms.

- CLASSIC 2000 Seismic, Magnetic, Passive Infrared, & Monitor



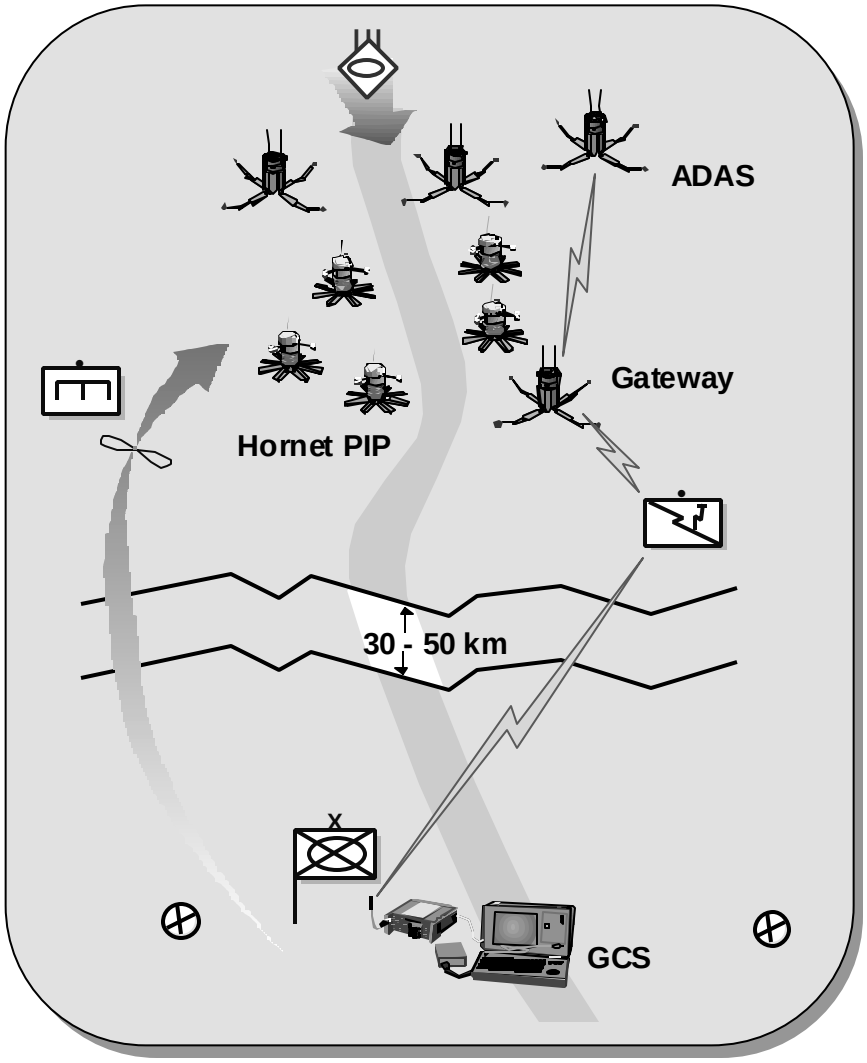
WHAT IS RAPTOR?

A Network of:
- **Sensors**
- **Gateways**
- **Munitions**
- **Control Station**



- *A smart, autonomous, anti-armor/vehicle system which increases lethality of its own Wide Area Munitions and other weapon systems through the synergistic effects of its munitions and sensors.*

CORE RAPTOR



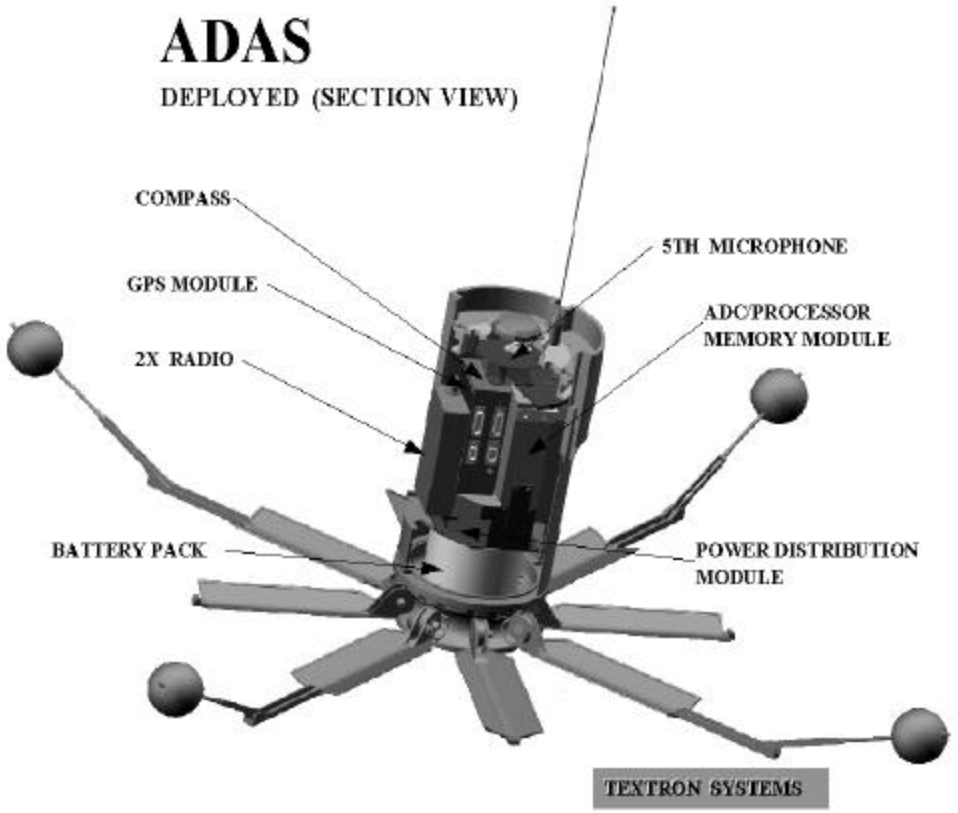
An Early Operational Capability for the Brigade Commander

- Remote Employment
  - ⇒ Up to 50 Kilometers from Control Station
  - ⇒ Delivered by Helicopter, Hand Emplaced
- Extended Communications
  - ⇒ Multiple Ground and/or Aerial Communication Relay
- Targets (detect, classify, track/locate, attack) – MUTIPLE TARGETS
  - ⇒ Heavy Wheeled and Tracked
  - ⇒ Light Wheeled and Tracked

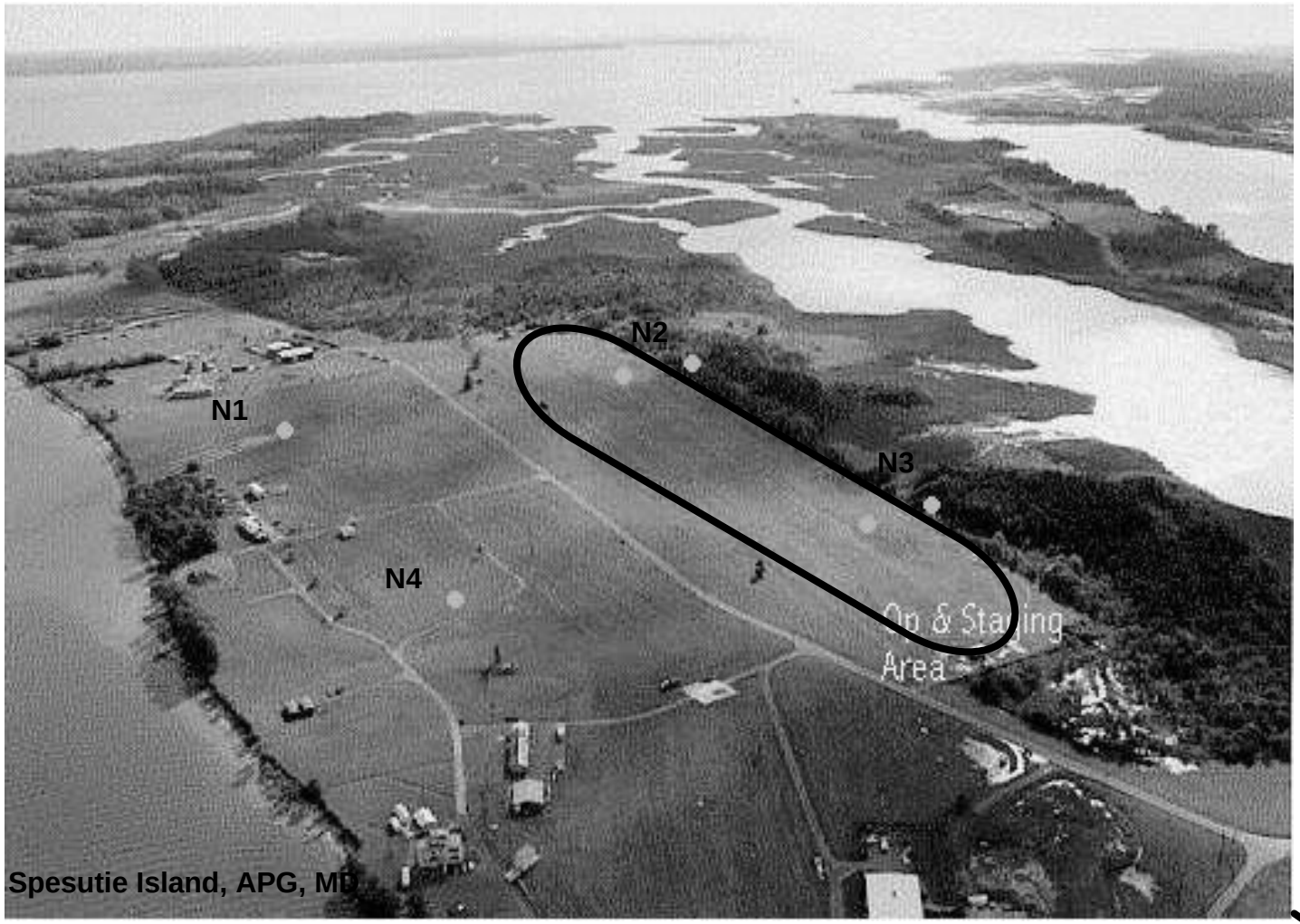
A Force XXI System

Current UGS Functions/Features

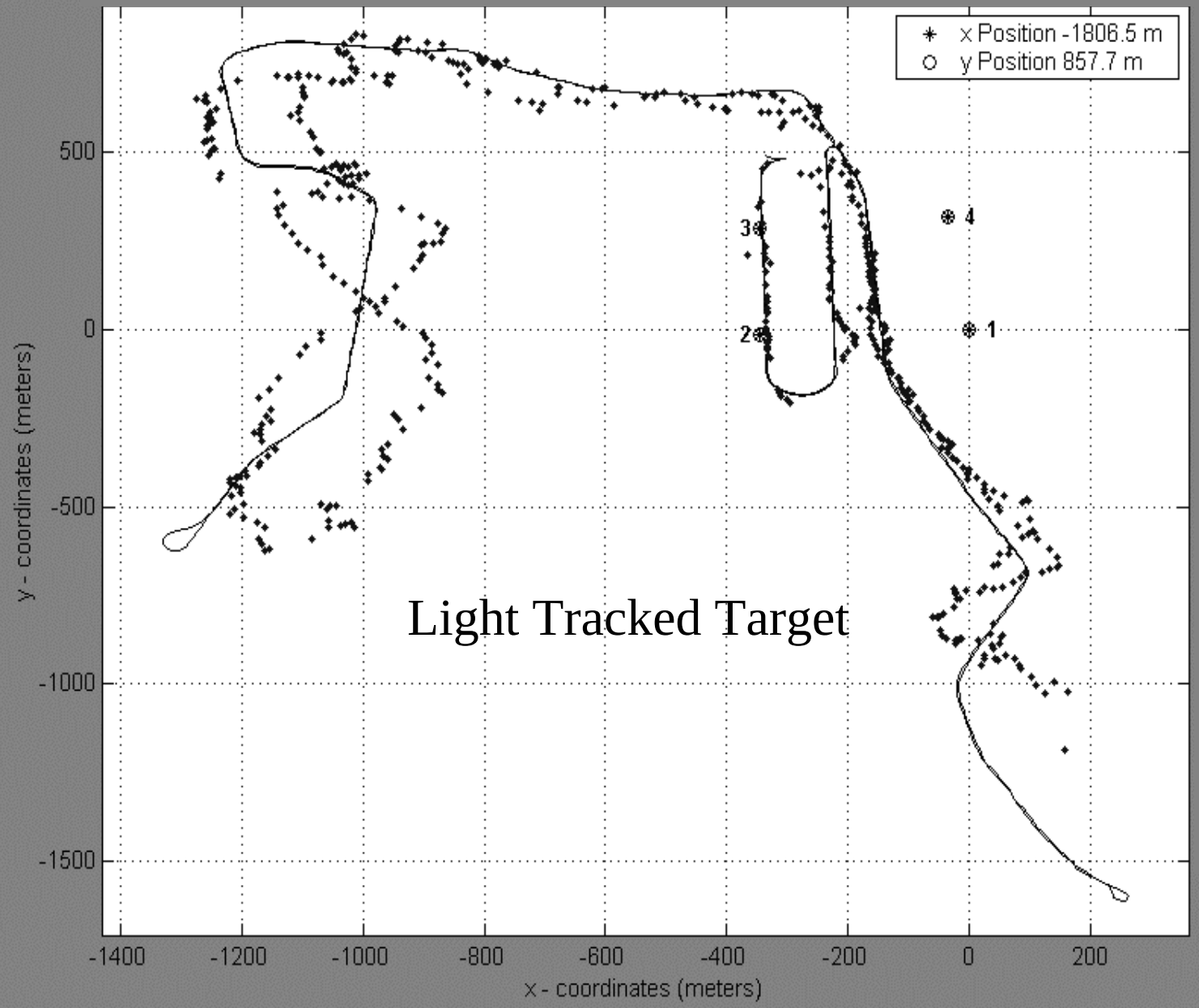
- Autonomous sensor networks deployed in clusters
- GPS, Compass, Radios
- DSP hardware/software
- Detection, Multiple Target Tracking, Classification
- Master/Slave Data Fusion
- Early Warning for Munitions & TOC
- Target Info for Long Range Shooters/Hunters



IASFT SENSOR LAYOUT



Current UGS Systems



Detection
M60 – 4km

Tracking
4 Targets
Simultaneously

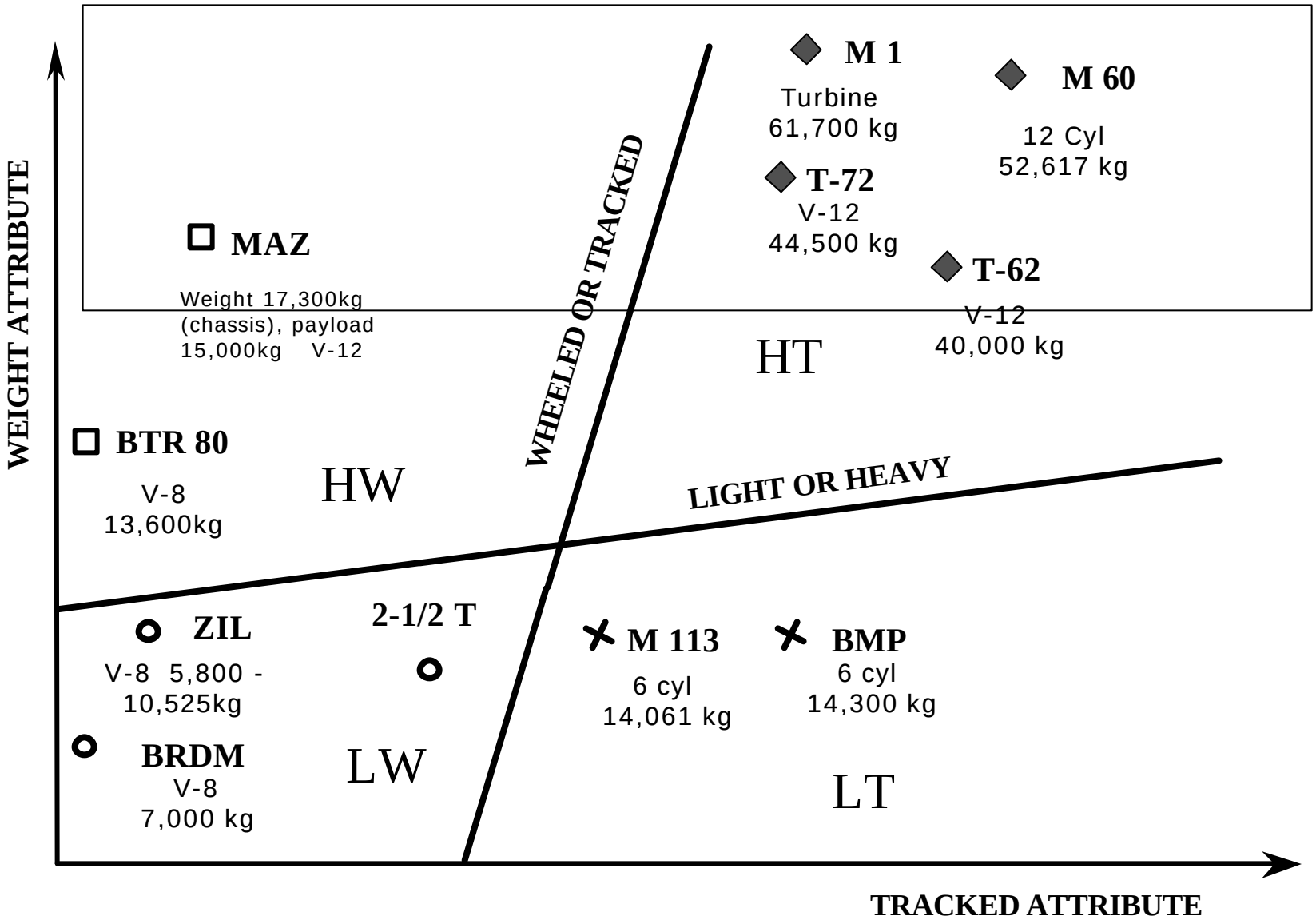
Classification
M60 – 3km

Target Class
Heavy Tracked
Heavy Wheeled
Light Tracked
Light Wheeled

Algorithm Development for RAPTOR

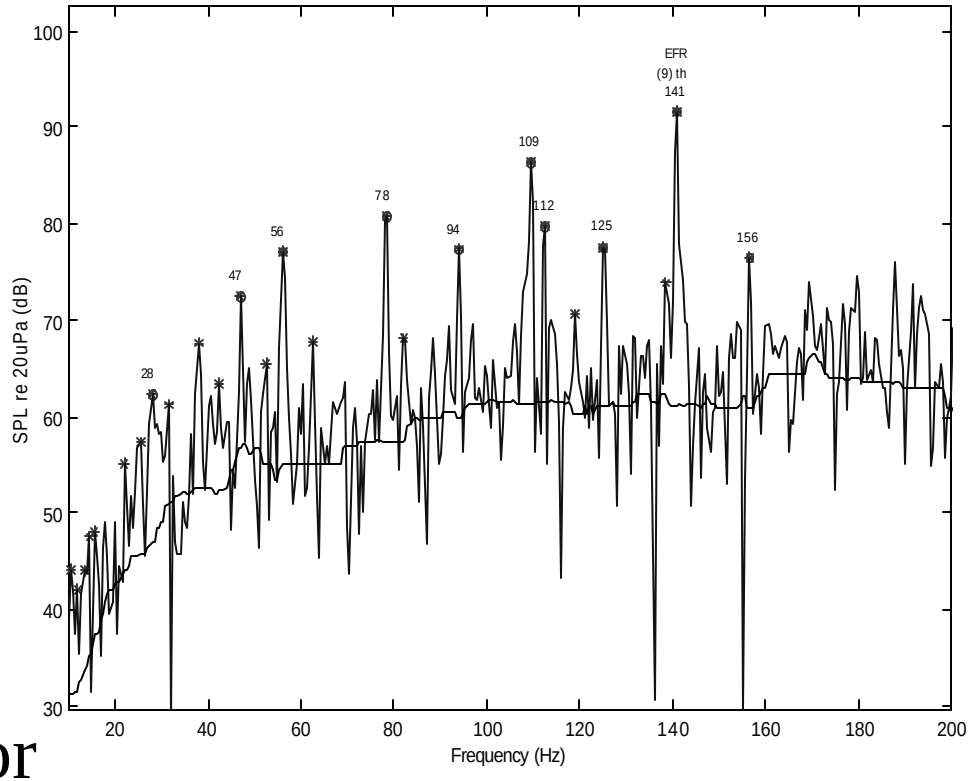
- ***Two Areas of development:***
  - ***<u>Classification</u> - Cylinder Counting Algorithm***
    - ***Template Based Approach – Using HLA information***
    - ***Statistically Enhanced using naïve Bayesian classifier***
  - ***<u>Tracking</u> - Target Counting Algorithm***
    - ***Requires Enhanced Directivity Using Adaptive Beamforming***
    - ***Null – Steered Response useful***
    - ***Minimum Variance Distortionless Response***

RAPTOR Vehicle Classifier



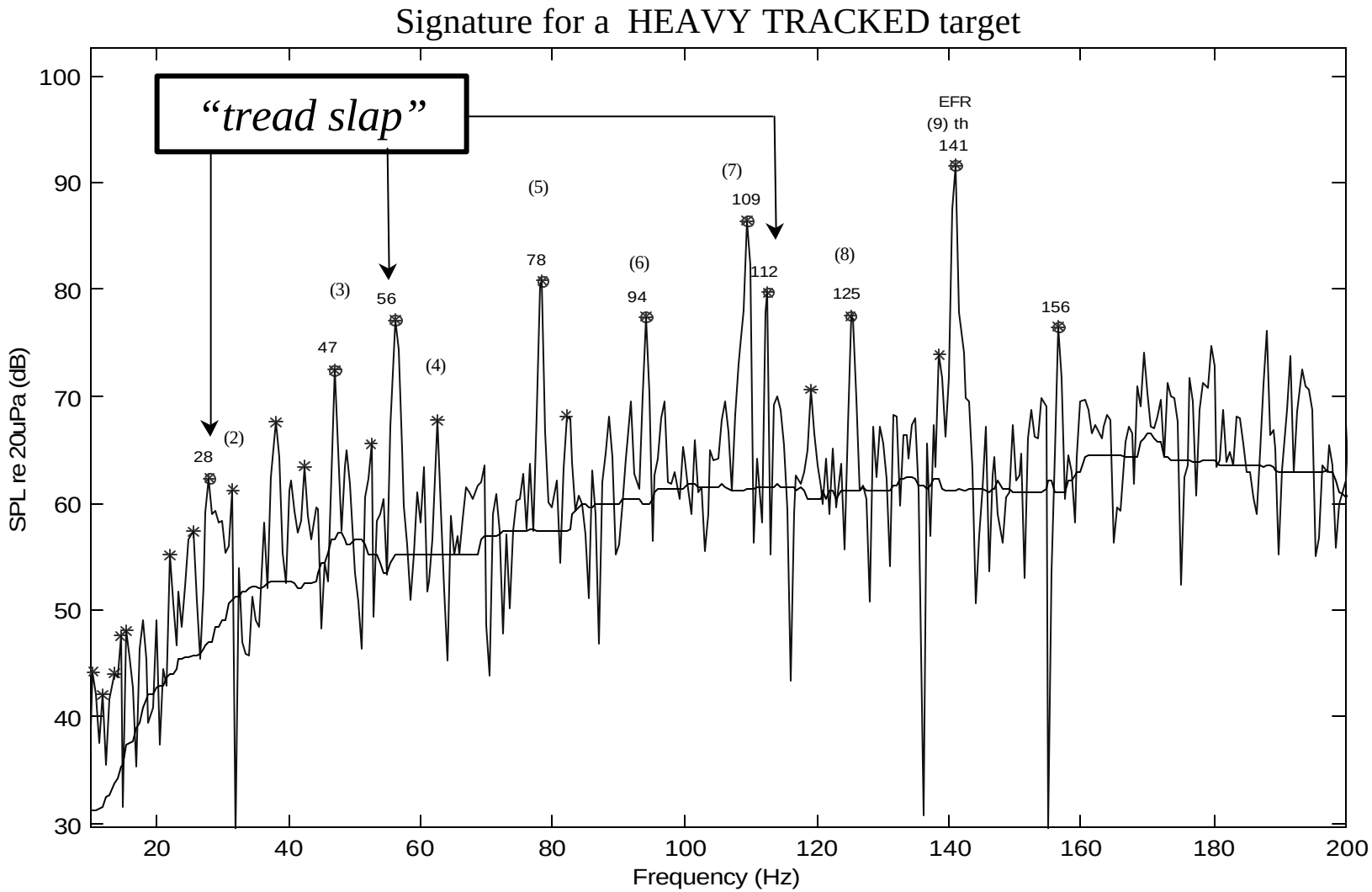
Classification Algorithm Development

- Frequency domain features – spectral content
- Harmonically associated spectral components
- Clustered according to number of cylinders & target type
- Statistical properties tabulated
- Bayesian statistics used for classification algorithms

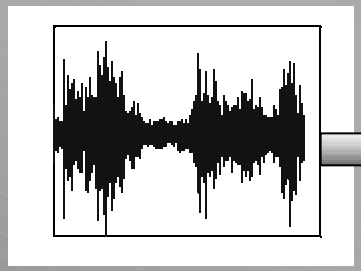


Classifier Improvements for RAPTOR

- *The identification of HLA templates relies on the 3 tallest harmonics* (e.g. **9 – 7 – 5** for T72) 6 %



Cylinder Counting Algorithm



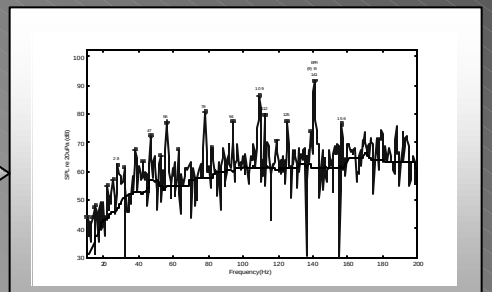
Load signature from file

FFT

Obtain Spectrum

Median Filter

Calculate Noise Floor



Identify Peaks > 10dB

Tallest Peak

Determine EFR

Group Harmonically Related Peaks

Perform HLA

Retain 3 Tallest Peaks

Extract Features

Database Compare

Template Database

Perform Template Match

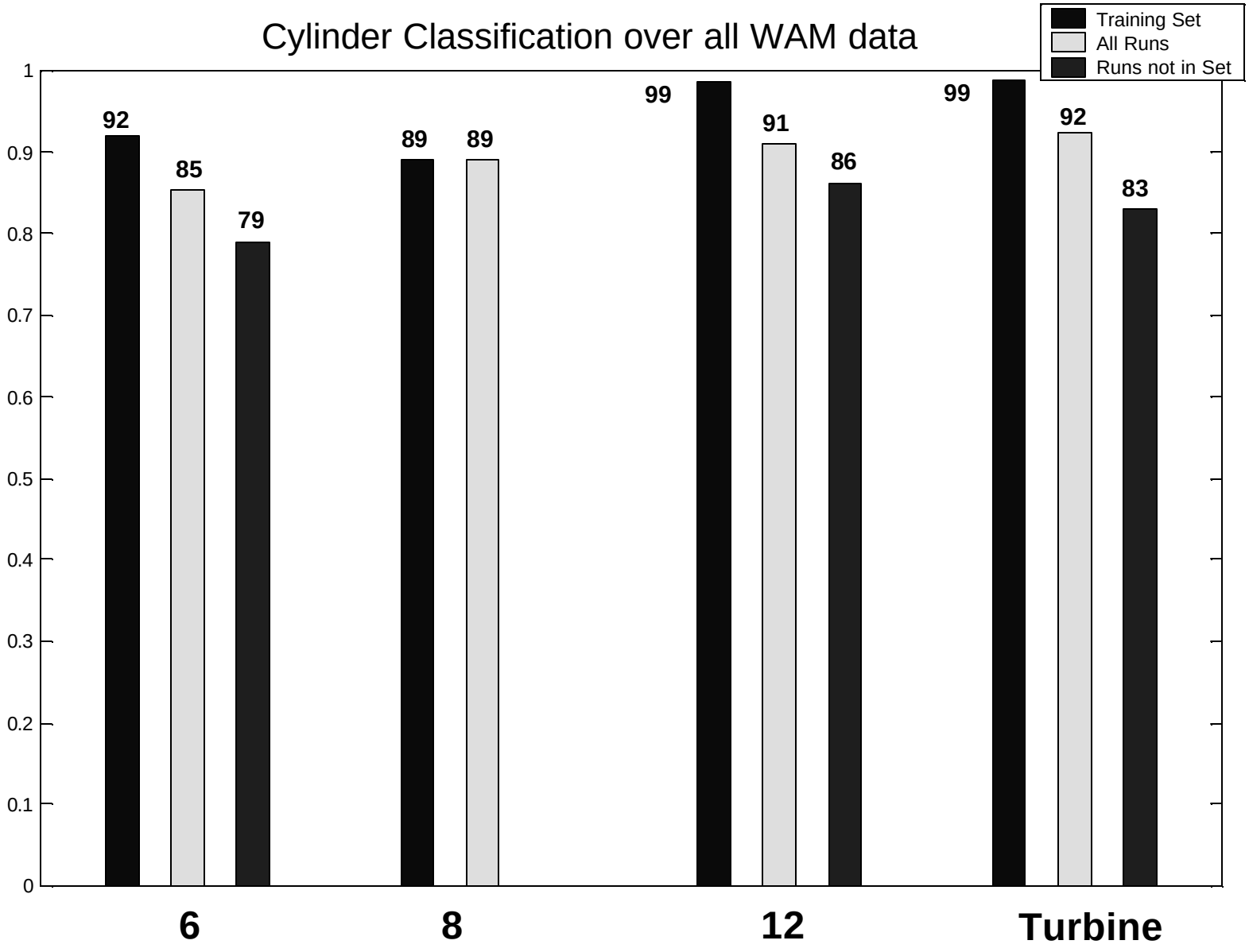
Discrimination

Estimate Number of Cylinders

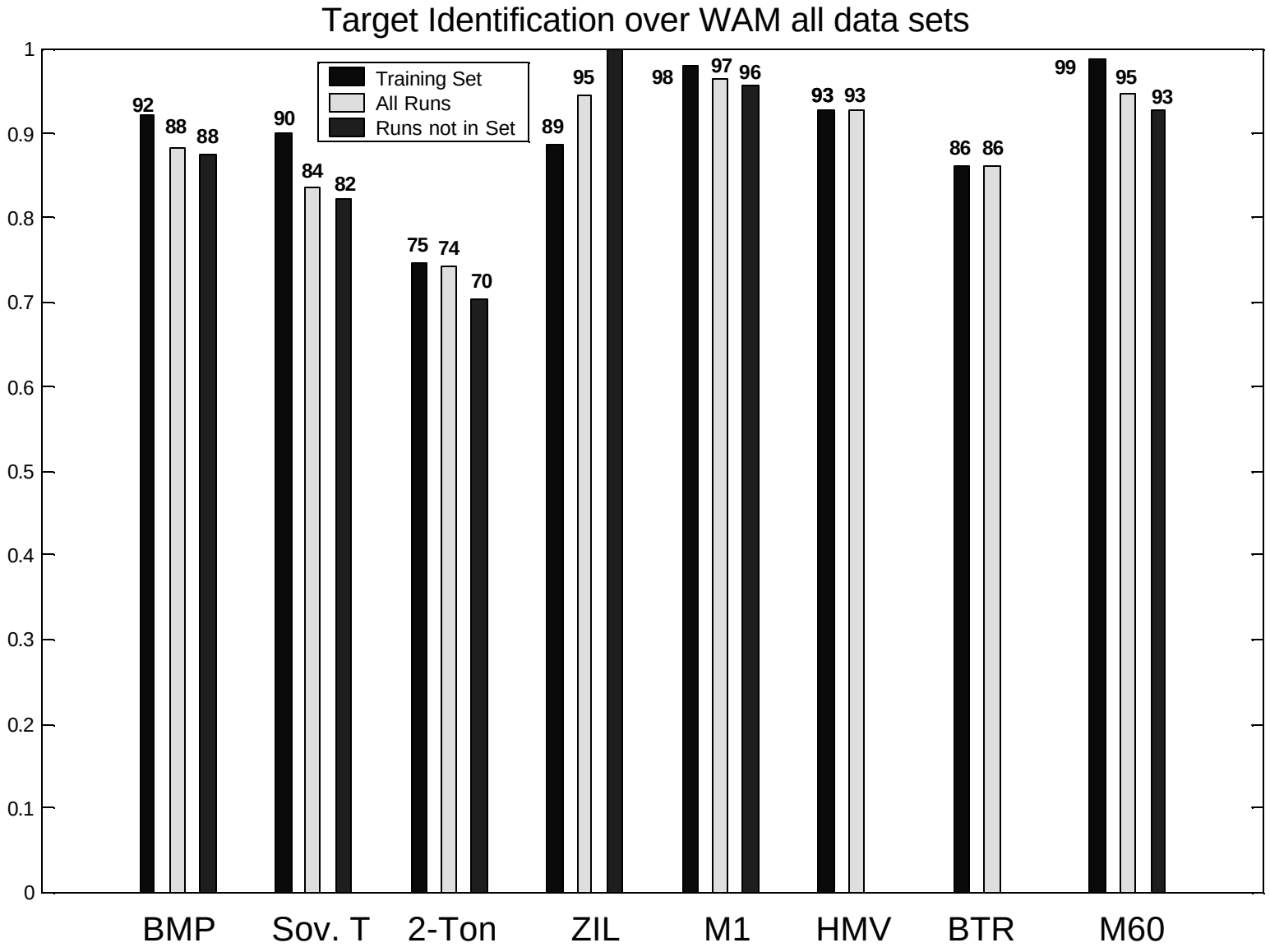
Classification

Cylinder Attribute

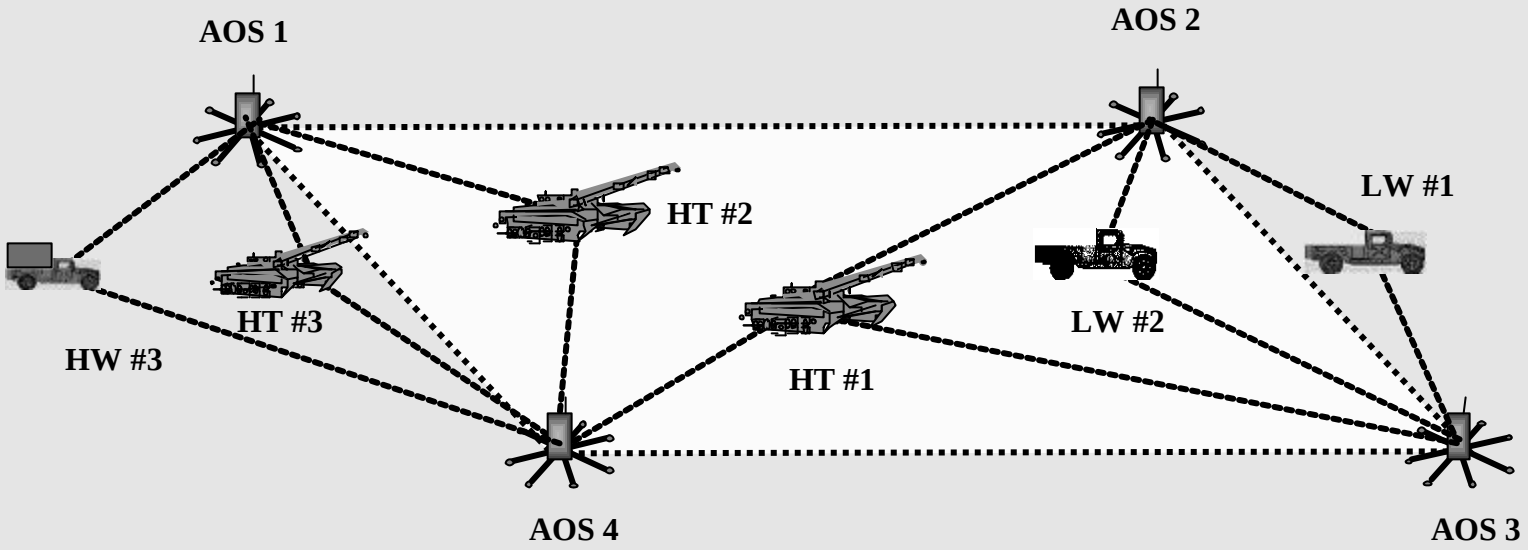
Classification Algorithm Results



Classification Algorithm Results



Target Counting Algorithms

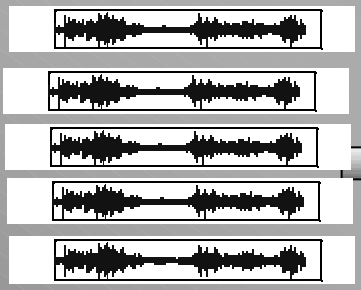


- Threat tracked as a “target mass” at long ranges
- Decomposed into list of individual targets at closer ranges
- Target tracking maintained throughout scenario

Target Counting Algorithm

- **Preliminaries**
  - *Requires superior bearing resolution*
  - *MATLAB program to test beams for different array geometries and apertures*
  - *Try adaptive beamforming methods to check the feasibility of assumptions made*
  - *Nullsteering, Optimal Beamformer response is determined as weights are obtained*
  - *MVDR solution*

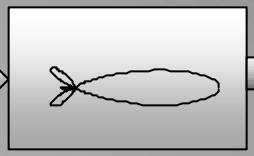
Target Counting Algorithm



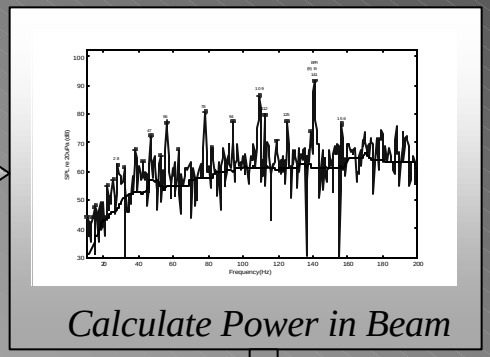
Load microphone data from file

FFT

Obtain Spectrum



MVDR Beamformer



Calculate Power in Beam

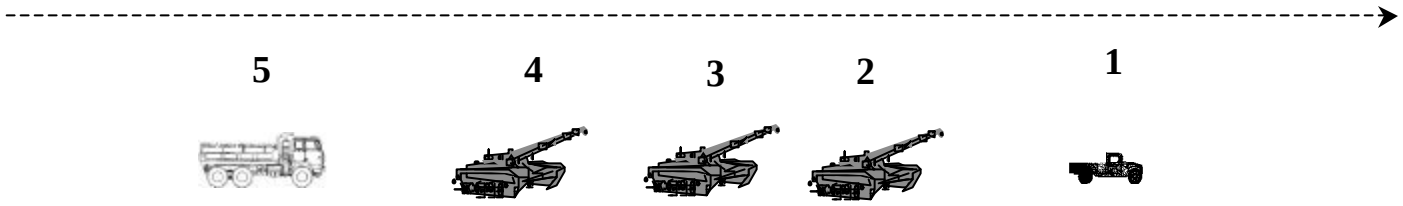
Current Power Spectral Density

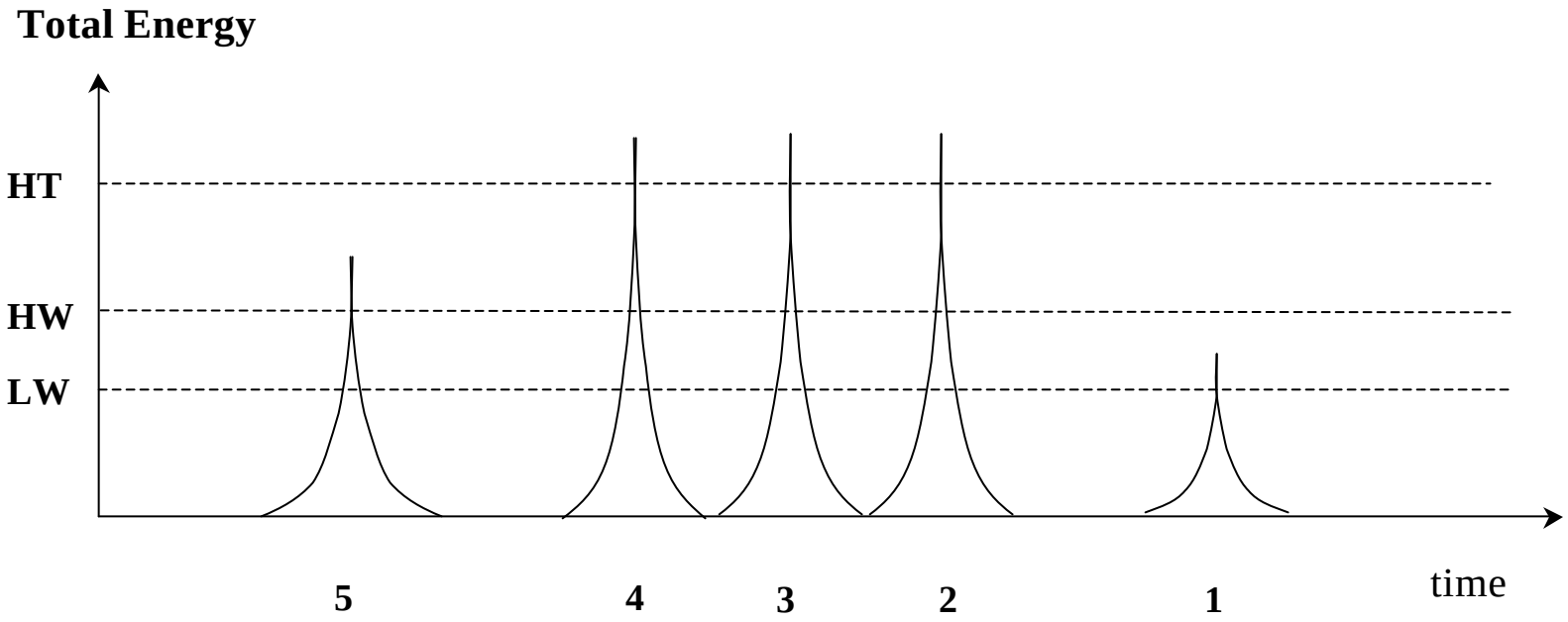
Compare with PSD at *t-1*

Fuse Results from all sensors

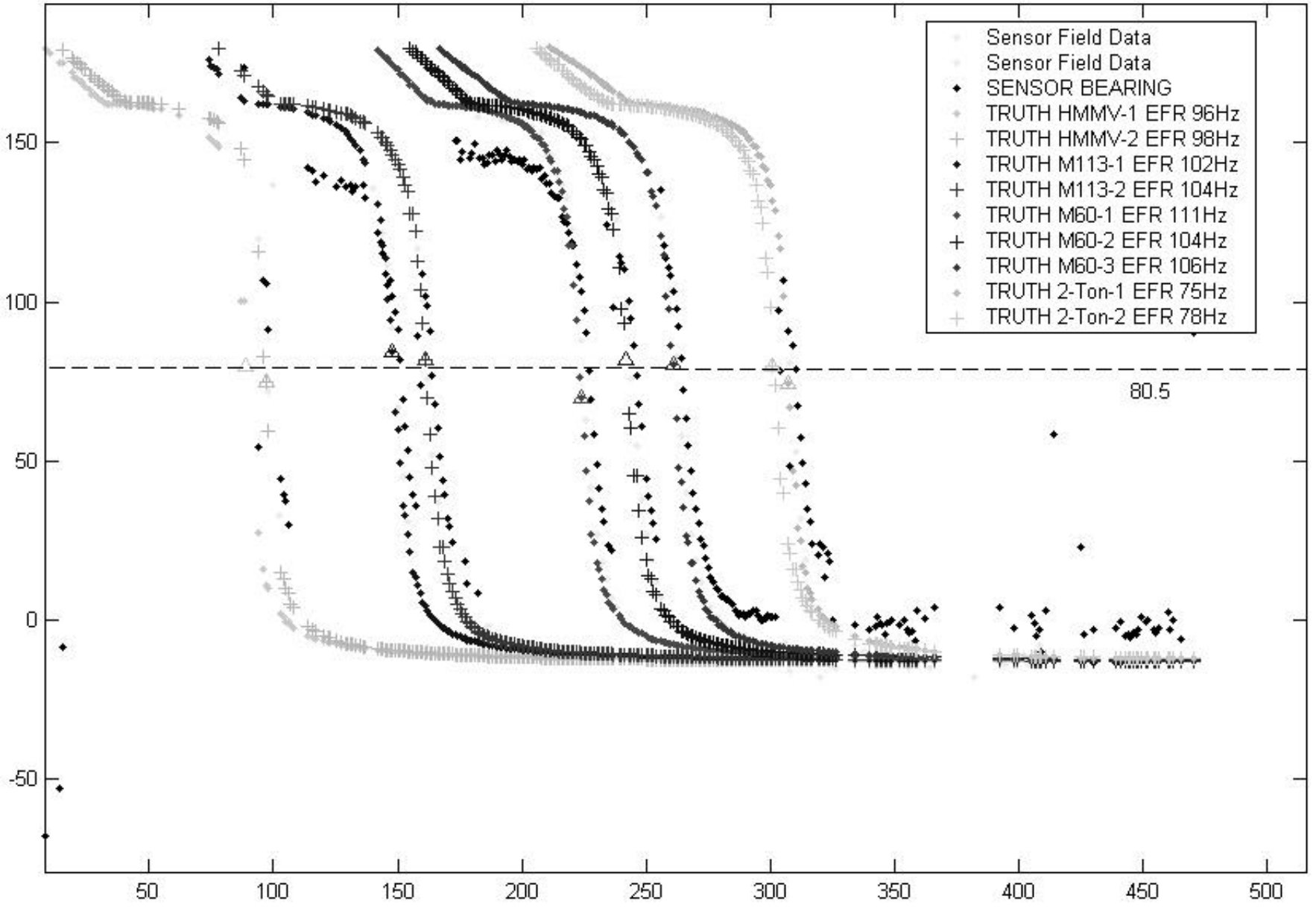
Scenario Assessment

Target Counting Algorithm





Multiple Target Tracking & Counting



Summary

- *Algorithm Development using MATLAB/SIMULINK*
- *Extensive Signature Databases w/ Ground Truth*
- *Sensor Hardware / MATLAB models*
  - *IAS Overwatch Sensor*
  - *Wide Area Munition (WAM)Sensor*
- *Currently working on*
  - *Target Classification*
  - *Multiple Target Tracking*